

THE MONTHLY NEWS MAGAZINE OF THE NATIONAL BUREAU OF STANDARDS November 1975

# DIMENSIONS

NBS

HEAT PUMP AT HOME



A PUBLICATION OF THE UNITED STATES DEPARTMENT OF COMMERCE

# DIMENSIONS

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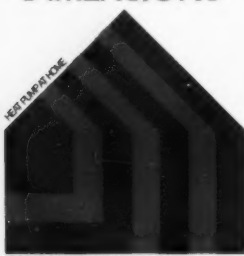
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Cover: Heat Pumps are growing in popularity as an economical means of heating and cooling homes and other buildings. The story beginning on the opposite page explains the heat pump and explores the popularity.

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The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

The Institute for Computer Sciences and Technology

Center for Radiation Research

Center for Building Technology

Center for Consumer Product Technology

Center for Fire Research

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# IS THERE A HEAT PUMP IN YOUR FUTURE?

**I**n the early 1800's a young French engineer named Sadi Carnot described the principles of a device which he said would be the most efficient way to produce heat energy. Few people then suspected that Carnot's reverse heat engine cycle, as he called it, would provide the basis nearly 150 years later for the modern-day heat pump, now becoming popular as a way to supply economical year-round heating and cooling for residences and other buildings.

Basically the heat pump, which typically runs on electricity, works like a refrigerator or air conditioner. It transfers the heat present in air (even at very low temperatures) from one place at a relatively low temperature to another place at a higher temperature.

The heat pump's newfound popularity stems from the public's increased awareness of energy conservation, and from the fact that in many regions today new buildings can no longer be hooked up to existing gas lines. Tight supplies and escalating prices are also making fuel oil less attractive. As a result, there was a large increase in the number of new dwellings built last year which are heated with electricity. With the

soaring cost of electric resistance heating, heat pumps offer the opportunity to conserve energy and money for home heating and cooling.

Along with equipment manufacturers, home builders, and buyers, researchers at the National Bureau of Standards are taking a fresh look at heat pumps. A team of engineers led by Dr. David Didion in the Center for Building Technology is investigating how the performance of heat pumps compares with that of traditional fossil-fuel heating equipment such as gas- or oil-fired furnaces and boilers, and with electrical resistance heating systems, such as electric furnaces and baseboard units. The research program in heat pumps is a part of a larger effort to develop test methods for heating and cooling equipment and systems for use in

consensus standards that would evaluate both part-load and full-load performance and provide a reliable basis for determining seasonal or annual efficiency and energy uses. The research is coordinated by the NBS Office of Energy Conservation in the Center for Building Technology (CBT) and is partly funded by the Federal Energy Administration.

## New Popularity

To understand the new popularity of heat pumps, it is necessary to understand how they work.

When a heat pump is used for heating purposes, cool air outside the building is blown over an even colder evaporator coil. Heat is transferred from the outdoor air to evaporate the liquid refrigerant in the coil, which is raised above room temperature by compression and then condensed in the indoor coil, transferring heat to the indoor air. A fan blows the warm air through ducts to the rooms to be heated.

When a heat pump is used for cooling and dehumidification, the functions of the indoor and outdoor coils, as described above, are reversed. In this case, heat is absorbed in the indoor coil to evaporate the

*turn page*

## Heat Pump *continued*

liquid refrigerant and is discharged through the outdoor coil after having its temperature raised above outdoor temperature by compression. This is a typical air conditioning process.

So although it is operated by electricity, the heat pump's economic appeal for home heating lies in the fact that the amount of heat delivered may be two or more times as much as that available if the electricity were used directly in resistance heating, the most common form of electrical heating. As a result, a heat pump may reduce electric heating bills by 30 to 50 percent or more, depending on the climate. When engineers talk about this advantage of heat pumps, they refer to the efficiency or Coefficient of Performance (COP).

The COP is the ratio of the useful heat energy transferred to the amount of energy put in the system. For a gas- or oil-fired furnace, this ratio is known as efficiency and is always less than one because heat is lost in the system through exhaust ducting and jacket walls. But when a heat pump is used for heating purposes, the COP is theoretically at least one and may be substantially larger. This is because the energy available for heating comes not only from the work energy put into the heat pump's compressor and indoor fan, but also from the heat extracted from the outdoor environment. When the heat pump is used for cooling, the COP is similar to that of an air conditioner, which is also greater than one. In general, the COP increases as the temperature differences over which it must pump decrease. For that reason, heat pumps have been used mostly for heating purposes in the Southern United States, where the

winters are not too severe and air conditioning is desired.

### Early Failures

NBS involvement with heat pumps is not new. In the late 1950's the U.S. Air Force, which had been buying heat pumps for military housing, came to NBS for help when failures began to show up in epidemic proportions. In 1959 the Air Force stopped buying new equipment and started to analyze the performance of some 9,000 heat pumps that were operating in Air Force housing projects. Led by P. R. Achenbach of the then Building Research Division, NBS played an important role in evaluating the performance of these Air Force heat pumps. As a result, a list of reliability problems and potential solutions was compiled.

Industry responded by organizing a heat pump research project in 1963 under the sponsorship of the Edison Electric Institute in cooperation with the Carrier Electric Corporation. From this and the efforts of other manufacturers, the second generation of heat pumps that are in use today was born. These improved heat pumps have proven very reliable when a proper maintenance program is followed. With the advent of the energy crisis, the military renewed its interest in heat pumps and requested that NBS develop a specification for procuring heat pumps. NBS engineers Clinton Phillips, Bradley Peavy, and William Mulroy developed the performance criteria necessary for such a purchase specification which encourages conservation.

Recognizing that reliability is no longer the major problem, the NBS research is aimed at determining the actual operating performance of com-

mercially available and innovative heat pumps. According to Didion, "One of the key questions is how competitive are heat pumps with other heating and cooling systems. At the present time, industry rates various heating devices using a steady-state, full-load test procedure. This means the device is tested while it is in continuous operation under maximum operating conditions. In real life, however, most heating and cooling units cycle on and off. This is called a part-load or dynamic basis. We want to develop a laboratory (factory) test procedure which will approximate more closely the actual efficiency under field conditions."

The job of investigating the field performance of a heat pump was made easier for NBS engineer George Kelly by the existence of a 22-year old house on the Bureau's grounds in Gaithersburg, Md. The Bowman house, as it is called, is a single-story

*Field tests at house on NBS grounds provide insight into practical operation of heat pumps.*



frame ranch-type house with a floor area of 232 square meters (2500 sq ft). The house is being used as part of a larger program, partly funded by FEA, to experimentally measure the energy savings which could be achieved through retrofitting—installing storm windows, insulation, weather stripping, and caulking.

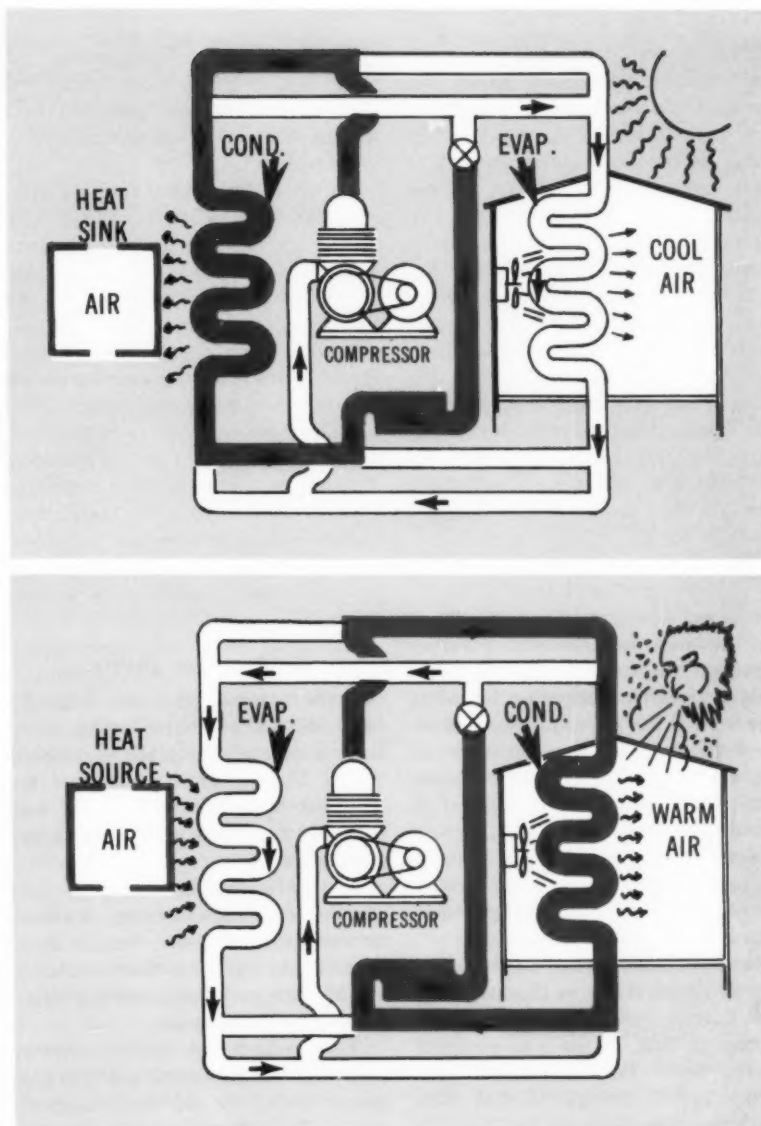
Originally heated by an oil-fired furnace, the Bowman house was outfitted with a 5-ton heat pump in the spring of 1974, and the oil furnace was removed. Kelly instrumented the heat pump to measure the amount of energy needed for heating and cooling. Various measurements have been carried out both before and after the house was retrofitted with other energy conservation measures.

### Practical Problems

"The data collected point up some of the practical limitations with heat-pump performance and rating methods as they now exist," Didion says. For instance, Kelly estimates that the seasonal heating COP of the Bowman house heat pump is about 1.75. This turned out to be about 19 percent lower than the seasonal heating COP calculated from performance data supplied by the manufacturer. The difference, says Kelly, is due to the effect of part-load operation as well as to ice buildup and defrosting on the outside coils.

Kelly explains that the effect of part-load operation on the performance of the Bowman house heat pump is greatest when the heat pump operates in the cooling mode, mainly because the heat pump is located in the basement of the house. In the heating mode, the residual heat contained in the indoor unit of the pump when

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Shown above are the cooling cycle of a heat pump (top) and the heating cycle (bottom). Two types of heat pumps are used in homes—room units and central system units. Designed for window,

through-the-wall, and free-standing installation, room units discharge warm and cool air directly into the conditioned area (one or two rooms). Central units can heat and cool a whole house.



# RESEARCH PROVIDES NEW INSIGHT INTO OZONE CONTROVERSY

**T**HE theory that fluorocarbons are depleting the ozone shield that protects the earth and all life from the sun's harmful ultraviolet rays first came before an unsuspecting public only last year, but already it has touched off a controversy of major proportion. According to the theory, fluorocarbons—chemicals that are widely used as refrigerants, aerosol propellants, and foam blowing agents—rise into the upper atmosphere where they break down under the sun's influence. The theory goes on to propose that the breakdown products from the fluorocarbons, specifically chlorine atoms, initiate a chain reaction that results in the destruction of ozone.

The theory was proposed last year by Dr. Mario J. Molina and Dr. F. Sherwood Rowland, two chemists at the University of California in Irvine. Although the theory received wide publicity and was accepted by many researchers, the actual photochemical mechanisms for the decomposition of the fluorocarbons had never been firmly established. Other pieces of the theory—such as confirmation of the presence of large concentrations of fluorocarbons in the upper atmosphere—also lacked experimental evidence.

Now two chemists at the National Bureau of Standards in Gaithersburg, Md., have provided the most detailed picture to date of the way sunlight breaks down fluorocarbons in the earth's upper atmosphere. The NBS research, carried out by Dr. Pierre J. Ausloos and Dr. Richard E. Rebert in the Institute for Materials Research, provides convincing evidence that up to two chlorine atoms are formed from each molecule of fluorocarbon

11 (CFCl<sub>3</sub>) or fluorocarbon 12 (CF<sub>2</sub>Cl<sub>2</sub>) that breaks down under the high energy, ultraviolet radiation present in the earth's upper atmosphere (stratosphere).

At almost the same time the NBS chemists reported their findings, scientists at the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colo., reported the first experimental data confirming the presence of predicted concentrations of fluorocarbons in the stratosphere. The NOAA scientists, working in collaboration with scientists at the National Center for Atmospheric Research (NCAR) in Boulder, also confirmed that the fluorocarbons are not consumed by any chemical or natural process in the earth's lower atmosphere.

## Evidence for Theory

Taken together, the new research from NBS, NOAA, and NCAR confirms a part of the Molina-Rowland theory. The research is expected to be used by scientists studying the effects of fluorocarbon breakdown on the earth's ozone layer. It is also expected to be used by various groups awaiting such data in order to make recommendations to the United States Government on the continued use of fluorocarbons as aerosol propellants and refrigerants.

Fluorocarbons 11 and 12 were chosen as the subject of the NBS research since they are the two most widely used fluorocarbons. Fluorocarbon 11 is used mainly as a propellant in aerosols and as a blowing agent for foam in insulation, cushions, sealants, and other materials. Fluorocarbon 12 is used extensively

as a coolant in refrigeration and air conditioning systems. In all, the United States produced more than 387 thousand metric tons of fluorocarbons 11 and 12 in 1974.

Ausloos and Rebert studied the light-induced breakdown of fluorocarbons 11 and 12 at four different wavelengths in the ultraviolet region of the spectrum. Three of the four wavelengths are in the range of wavelengths that bring about most of the photochemical reactions in the stratosphere (ranging from about 10 to 70 kilometers above the earth). All other studies have been carried out at only one of the wavelengths in the range of interest.

At the longest wavelength at which fluorocarbons absorb light in the stratosphere, the chemists found that the breakdown of fluorocarbons is very efficient. In fact, they found that each photon (a discrete package of light) absorbed by a molecule of fluorocarbon results in the formation of one chlorine atom.

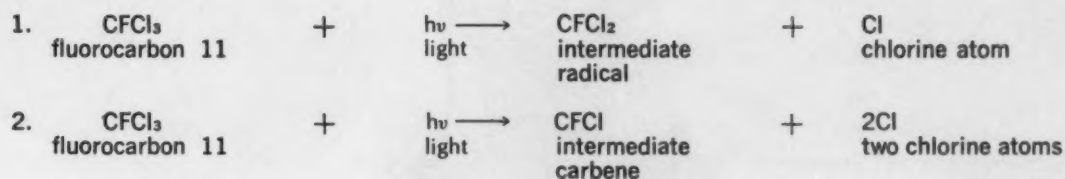
## Double Threat?

An additional finding was that as the wavelength decreases—and the energy of the photons increases—the probability increases that not one but two chlorine atoms are released as a result of the absorption of a photon by a fluorocarbon molecule. "This means of fluorocarbon breakdown has not been considered before," Ausloos reports.

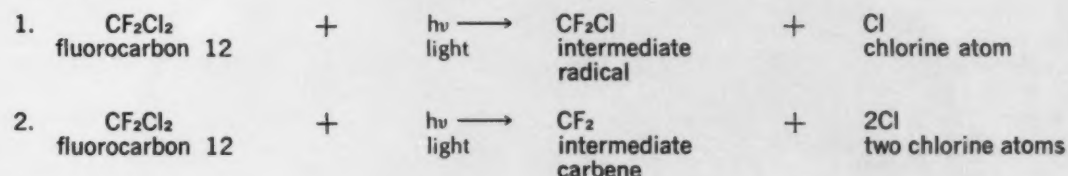
Do two chlorine atoms represent a double threat to the ozone layer? "Not necessarily," Ausloos explains. "Even before we carried out our research, other scientists had proposed that chemicals resulting from the breakdown of fluorocarbons reacted

Based on new NBS research, these are the major proposed mechanisms accounting for the light-induced breakdown of fluorocarbons 11 and 12 in the upper atmosphere:

#### Fluorocarbon 11



#### Fluorocarbon 12



further with oxygen, which could lead to the possible liberation of an additional chlorine atom. From a fundamental point of view, it is important for us to know whether chlorine atoms are formed by a direct or indirect mechanism." The NBS research indicates that they are formed by a direct mechanism.

Based on measurements of the breakdown products in the reactions they studied, Ausloos and Rebbert were able to propose multi-step processes for the decomposition of the fluorocarbons (see box).

One of the most important observations made during this research was the presence of two chemical species which are expected to be important in the complex chemistry of the upper atmosphere. The species,  $\text{CFCl}$  and  $\text{CF}_2$ , result from the breakdown of fluorocarbons 11 and 12, respectively, according to Ausloos. "Our

studies show that these species are relatively stable, but they are expected to react with oxygen in the atmosphere," he says. "Our research clarifies to a large degree the chemistry of these species, which until now has been mostly unknown."

Another finding in the NBS research is that fluorocarbons 11 and 12 absorb light less strongly as the temperature decreases at the longer wavelengths. Most studies dealing with the absorption of light by fluorocarbons have been carried out at room temperature (about 298 K), whereas the temperatures in the upper atmosphere are substantially lower (ranging from 190 to 275 K).

"Our studies indicate that for fluorocarbon 12 at the longest wavelength at which fluorocarbons absorb in the stratosphere there is a tenfold increase in the absorption cross section as the temperature increases

from 234 to 442K," Ausloos says. The absorption cross section is a measure of the probability that a molecule will absorb a photon of light. "This means the fluorocarbons probably have a longer lifetime before breaking down at the temperatures found in the stratosphere than has previously been believed. It also means that scientists who are carrying out computer modeling studies of the stratosphere should take temperature into account in their calculations whenever the absorption cross section is involved."

#### New Data Tables

Computer modeling studies continue to represent the major way in which scientists study the complex meteorology and chemistry of the stratosphere. Such studies are used to predict the effects of fluorocarbons and other chlorine-containing com-

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# PACING THE HEART RELIABLY

**A**N estimated 200,000 persons in the U.S. rely on battery-powered electronic pacemakers, implanted in the body, to regulate their heartbeats. Because it serves a life-sustaining function, the pacemaker must be extremely reliable for its complete term of use.

Even though the human body represents a hostile environment for the pacemaker, most of these devices are reliable and effective. However, pacemaker failure and malfunctions, caused principally by battery depletion, electronic failure, and material-related problems, do occur. Such failures often necessitate that the unit be replaced by surgery.

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The pacemaker industry is faced with problems similar in many aspects to those of the high reliability space and military communities.

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To address the technical questions involved with assuring cardiac pacemaker reliability, the National Bureau of Standards in July brought together for the first time experts from the pacemaker, electronics, and related communities in a workshop jointly sponsored by NBS and the Food and Drug Administration of the Department of Health, Education, and Wel-

fare. The workshop was attended by representatives of the 10 known domestic manufacturers of pacemakers and two of the five known distributors of foreign made pacemakers.

FDA concern about pacemakers arises from recent reports of pacemaker failures that have resulted in a number of deaths, and from a variety of component and material-related problems that have required the recall or more frequent monitoring of about 23,000 pacemakers.

According to workshop chairman Harry A. Schafft of the NBS Electronic Technology Division, the meeting was held to stimulate a heightened awareness of the available technology, a greater use of the expertise that exists outside the pacemaker industry, and a more productive participation in voluntary standards activities.

Involvement with pacemaker reliability stems from the Bureau's responsibilities to work with industrial representatives in facilitating effective application of the Nation's science and technology to produce the best products for the general public. NBS offers the pacemaker industry expertise in such areas as semiconductor device measurement technology, hermeticity testing, metallurgy, standards making, and technology transfer.

Schafft explains that the workshop

was designed to infuse into the pacemaker industry needed technology and expertise from other areas, particularly the high reliability semiconductor device community. Experts from a variety of disciplines and representatives of the pacemaker industry were brought together to discuss questions of mutual concern. The objective was to promote technical exchange of information.

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To prepare for organizing the workshop, members of the Electronic Technology Division visited pacemaker manufacturers in an effort to identify areas of interest that should be addressed at the meeting. According to Schafft, they found that much of the technology and the procedures of the high reliability semiconductor electronic community were already being transferred into the manufacture of pacemakers. They also found that many engineers, previously associated with high-reliability semiconductor

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## Heart continued

conductor electronics space and military programs, had brought valuable expertise to the pacemaker industry.

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**Reliability requirements for pacemakers are difficult to fulfill because high quality components are not "off-the-shelf" items.**

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In general, the Electronic Technology Division staff found an industry very much concerned with high reliability technologies and faced with problems similar in many aspects to those of the high reliability space and military communities. The industry identified 12 areas of interest, each arising out of a deficiency in the measurement technology:

Electronics—procurement and test of high reliability parts.

Hermeticity Testing—evaluation of methods; specification of leak rates and moisture concentration.

Weld Inspection—nondestructive methods.

Electromagnetic Interference (EMI)—characterization and control of electromagnetic environment.

Electrical Leads — evaluation and accelerated stress test methods.

Materials—characterization for corrosion, biocompatibility, and bondability.

Sterilization—evaluation and qualification of sterilization procedures.

Power Sources—qualification and comparison of batteries.

Accelerated Testing—qualification and comparison of products, assurance of quality control, and substantiation of reliability.

Standardization—procurement pro-

cedures, manufacturing processes and procedures, and tests.

Information Resources—availability of reliability and other data banks.

Service Resources—availability of procurement, manufacturing, and test services.

In the time available, the July workshop could address only five of the 12 areas identified, namely: electronics, hermeticity testing, standards, information resources, and service resources.

In the area of electronics, workshop participants wanted to know how best to obtain high reliability parts, which fabrication processes were best, and what should be included in the purchase specifications for a part.

These concerns stem in part from the industry's attempts to reduce pacemaker size and battery drain by the electronic circuit. These attempts have led to greater interest in increased integration and the use of newer and more sophisticated technologies.

Several points of considerable significance were raised. It was repeatedly emphasized that the reliability requirements for components to be used in pacemakers are more severe than all but the most stringent military and space requirements. These requirements take on new dimensions with the development and growing use of batteries with operating lives of 5, 10, or more years.

However, these reliability requirements for pacemakers are difficult to fulfill because high quality components are not "off-the-shelf" items. Additionally, there are no adequate standard or consensus process and

procurement procedures to purchase high reliability electronic parts, nor are there clearly satisfactory means to test their reliability with confidence. It was therefore not surprising to see an intense interest by attendees in the problems of obtaining and assuring the reliability of the high quality components needed for pacemakers and other such demanding applications.

One speaker from the Rome Air Development Center stated that manufacturers of pacemakers are probably using military standard class B parts or their equivalents. He urged the manufacturers to demand that vendors add production lines for class A parts, with failure rates of one in one billion (at least 10 times the mean time before failure for class B parts). According to Judson C. French, chief of the Electronic Technology Division, such production will require manufacturing control and measurement methods similar to those currently being worked on by the NBS Semiconductor Technology Program.

A major governmental policy question was raised in the discussion following a presentation of the description of a government program to develop highly reliable hybrid circuits for an application to nuclear weapons. It was observed that no government agency has the authority or responsibility for development of methods to permit assured procurement of high quality electronic components for application to the solution of critical problems in the civilian sector. At the present time, developments in this area rely primarily on spin-off from military and space activity and on developments by an industry (the semiconductor

## CARDIAC PACEMAKERS

The rate of the heart is normally regulated by its own natural "pacemaker," the sinoatrial node, which produces electrical impulses at regular intervals. This "pacemaker" is located in the upper part of the heart.

A conductive path in the heart carries these impulses from the upper heart down to the lower heart and around to the outer muscle walls. Each impulse causes the heart to contract and pump blood.

In some individuals, the conductive path becomes blocked, either permanently or intermittently, for a variety of reasons.

When this happens, the pacemaker signals do not get to the lower heart due to a condition called heart block.

Electronic pacemakers are used when natural impulses are blocked or are too slow to stimulate the heart to pump a sufficient supply of blood. The electronic pacemaker produces electrical impulses just strong enough to cause the heart to contract.

A pacemaker consists of:

The *pulse generator*, which actually produces the electrical impulses. This is usually implanted just under the skin, either just below the collarbone or in the abdominal wall.

The *lead*, which delivers these impulses to the heart. Pacemaker leads may be attached to the outside of the

heart or, more often, inserted through a vein to go directly to the inside of the lower heart.

Pacemakers can be *fixed rate* or *demand*. Fixed rate (or asynchronous) pacemakers deliver impulses to the heart continuously at a preset rate. Demand (or standby) pacemakers have a preset rate, but are designed to stimulate the heart only when the natural heart rate falls below the preset rate of the pacemaker. When the heart is beating normally, the demand pacemaker will simply "standby."

The material in this section was taken from a variety of sources, notably "Pacing the Heart Electronically" by Glenn A. Rahmoeller and James R. Veale, published by the Office of Medical Devices, Food and Drug Administration.

device industry) principally oriented to the production of good quality parts in high volume rather than high reliability parts in low volume.

During the workshop session dealing with hermeticity testing, speakers addressed problems of determining the maximum acceptable leak rates for their parts and pacemakers, and determining how much internal moisture can be tolerated.

Two speakers addressed the many unresolved problems associated with measuring hermeticity of the large enclosures typical of pacemaker units and the difficulties with the correlations of moisture penetration with measured leak rate.

The problem of sealed-in moisture was also raised. This can occur from a variety of causes ranging from the obvious case of moisture in the sealing atmosphere to the almost undetectable case of minute quantities of moisture entrapped within materials used in making the unit.

A third speaker described two examples of failures of hermetically sealed integrated circuits through the interaction of sealed-in moisture and extremely small amounts of ionic contamination. He explained that these circuits had passed all tests for both fine and gross leaks and standard burn-in cycles. However, after periods of operation as short as 50

hours, failure occurred due to deplating of gold causing electrical short circuits between metallization stripes. A longer term (2 to 3 year) failure mechanism due to corrosion effects was also observed. These examples are indicative of the subtlety of some of the problems which can result in failure of an electronic system.

To encourage a more productive participation in standardization work by the cardiac pacemaker community, speakers presented overviews of the organization and activities of the Association for the Advancement of Medical Instrumentation, the American Society for Testing Materials

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## Research at NBS Makes Compatible Two Techniques in Preventive Dentistry

# Fluorides & Sealants

STOPPING CAVITIES BEFORE THEY START

**I**N the future, when your son or daughter dashes in from the dentist with the latest cavity count, the news may be better thanks to the work of researchers at the National Bureau of Standards.

Working in collaboration with the National Institute of Dental Research and the American Dental Association (ADA) Health Foundation, NBS is helping to develop new and better techniques in preventive dentistry. Recent work by the ADA Health Foundation Research Unit in the Polymers Division promises a method to combine, to advantage, two previously incompatible techniques—topical fluoridation of teeth and application of a tooth sealant.

Topical fluoridation of teeth—the direct application of a fluoride com-



pound to the teeth, is not new; it has been practiced since the late 1940's.

Just why fluoridation helps teeth is not known for certain, according to Dr. Walter Brown, director of the ADA unit at NBS. Favorite explanations include a chemical theory—fluoride reduces the solubility of tooth material; a biological theory—fluoride affects the metabolism of the bacteria that cause tooth decay; and a physical theory—fluoride affects the charges on the surface of the tooth, inhibiting the retention of plaque.

The other technique, use of a pit-and-fissure sealant, is comparatively recent. It has been in commercial use for only 3 to 4 years. The sealant is "painted" on the teeth as a viscous liquid. Depending on the commercial brand, the sealant is hardened with a chemical additive, like an epoxy cement, or by means of an ultraviolet lamp.

The effect of the sealant is to fill in undesirable depressions and crevices in the chewing surfaces on bicuspids and molars and thus prevent the accumulation of food, debris, and bacteria that lead to the formation of cavities.

Sealing is still a somewhat controversial technique, according to Dr. Laurence Chow of the ADA Research Unit. Its chief drawback is impermanence. While metal fillings are expected to last at least 5 years, the present "life expectancy" of a sealant is about 2 years. Some dentists believe that a fissure deep enough to require a sealant should be filled with a conventional metal amalgam as a preventive measure, even though no decay can be detected.

On the other hand, said Chow,

sealing is "potentially the best technique." Since no drilling of teeth is involved, it is also cheaper. It uses no costly metals, and it requires less time and effort.

One major problem with sealants has been getting the polymer to adhere or "bond" to the tooth. There is little physiochemical bond between tooth enamel and sealant material. This problem was partially solved in the late 60's by Dr. Michael Buonocore, of the Eastman Dental Center in Rochester, N.Y., who developed the technique of "etching" the tooth by applying a 50 percent phosphoric acid solution for about a minute. The acid etch leaves the tooth surface porous and rough, allowing for a tight mechanical bond.

The currently preferred sealant, a monomer known as BIS-GMA, was developed at NBS in the early 60's as a binder for reinforcing the material for filling teeth, by Dr. Rafael Bowen, associate director of the ADA Research Unit.

The idea behind combining fluoridation and sealing, according to Bowen, is that fluoridation is more effective on the smooth surface of the teeth where the sealant is least retentive. The sealants are most effective in the pits and fissures, where fluoride treatments are least effective.

Sealing is still a temporary measure—used quite often by dentists for small children whose teeth are still forming. The sealant will wear off, and in the meantime fluoride should be introduced to give added resistance to "caries," the formation of cavities.

Until now, topical fluoridation, considered one of the most effective methods of introducing fluoride to tooth enamel, could not be used

when a sealant was to be applied. Now it may be possible, according to Chow.

"We are not the first to try this," said Chow, "People have tried to apply fluoride before the sealant application. What they found is that after the fluoride is applied to the surface, the adhesion of sealant to tooth surface becomes substantially worse. Later it was found that this happens because of the presence of small spherical particles of calcium fluoride on the surface of the etched teeth."

The calcium fluoride particles act like a lubricant, causing the sealant to slip off the tooth. The process is comparable to painting over a dusty surface.

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*A therapist checks a young patient's teeth for plaque. The use of both sealants and fluoride treatments is most effective in the child's first 12 years of tooth formation.*



# HIGHLIGHTS

## **New Miniature Temperature Probe**

A miniature temperature probe developed by NBS meets a critical measurement need in medical research and cancer therapy. The new probe, unlike conventional thermometers, provides accurate measurement of temperature in human tissue and "phantom materials" during exposure to intense electromagnetic radiation. The NBS probe shows no induced heating in the presence of the intense fields used in bioeffects research and in diathermy. It can also be used in situations where electrical shock hazards are critical.

## **NBS/NIH Agreement**

NBS and the National Institutes of Health (NIH) will cooperate to develop ultrasonic signal processing techniques for medical diagnosis. The major goal of this project is to provide more sensitive ultrasonic techniques for the detection of abnormalities in tissue.

NBS will develop the test methods, using techniques and instrumentation similar to those being developed to test ceramics and metals. NIH will evaluate methods and instruments.

## **NBS Mercury Dosimeter**

A dosimeter for monitoring mercury vapor in air, small enough to be worn on workers' clothing, has been developed by NBS. The instrument uses a piezoelectric crystal operating as a gravimetric device which indicates an integrated total exposure to mercury vapor. The mass of the material deposited or absorbed is determined by measuring the change in oscillation frequency of the crystal.

Monitoring mercury at industrial work sites is necessary because mercury is both toxic and cumulative

and contamination must be controlled. The Bureau developed a personnel monitor, rather than a site monitor, because mercury concentrations vary greatly within individual work sites.

## **Atomic Clock Now Easily Portable**

Based on a commercially available rubidium standard, NBS has developed a portable rubidium clock much lighter than cesium clocks. Technical modifications which improve the temperature and magnetic environment characteristics allow stabilities of several parts in  $10^{12}$  during the period of a normal time transfer trip by commercial air transport.

This portable clock will assure easier high-precision national and international time comparisons. Since it weighs only 11 kg and can be carried by any traveler as hand luggage at no extra cost (in contrast to cesium standards which weigh on the order of 100 kg and require purchase of an extra seat as well as a 110-volt power connection), very frequent time comparisons become possible.

## **New Standard for COBOL-74**

NBS has published a revised Federal Information Processing Standard COBOL for use by all Federal agencies. COBOL is the major computer programming language used in non-scientific applications. COBOL-74 replaces the earlier Federal COBOL standard (COBOL-68), which has been a standard since 1972.

According to Dr. Ruth M. Davis, director of the NBS Institute for Computer Sciences and Technology, "This revised COBOL standard incorporates advanced programming features of the new national standard,

ANSI X3.23-1974, and reduces remaining impediments to wider interchange and transferability of COBOL software."

FIPS PUB 21-1, which contains the revised standard, is available from the U.S. Government Printing Office, Washington, D.C. 20402, SD Catalog No. C13.52:21-1 at \$4.90.

## **Agreement With Nuclear Regulatory Commission**

NBS has signed an agreement with the Nuclear Regulatory Commission (NRC) to develop ultrasonic nondestructive test methods for nuclear reactor monitoring. More sensitive ultrasonic test methods are needed to locate flaws in nuclear reactor assemblies which are not detectable by present techniques.

This agreement includes the development of test methods and instrumentation and application of the methods to the inspection of pipes and other specimens containing a variety of flaws. The reactor test specimens will be supplied by NRC.

## **Piezoelectric Effect in Bone and Teeth**

NBS is involved in a program to obtain piezoelectric measurements on bone and teeth as a function of temperature, relative humidity, frequency of the applied stress, and orientation of the sample. The piezoelectric effect in bone was discovered in Japan 20 years ago, but, to this date, the lack of a thorough characterization of the effect inhibits the utilization of piezoelectricity in medicine and dentistry. These studies will supply data for: (1) the use of piezoelectricity in orthodontia and orthopedics; (2) the design of synthetic dental and orthopedic implants. □

# NBS Three in the I-R 100: Radiometer, Laser Stabilizer, Dew/Frost Detector

**T**HREE inventions developed at the National Bureau of Standards have been listed among the top 100 technical products in 1975 by Industrial Research magazine.

The I-R 100 awards went to NBS scientists and engineers for development of an electrically calibrated pyroelectric radiometer, a high-speed laser intensity stabilizer, and a dew/frost point apparatus.

## Pyroelectric Radiometer

The radiometer measures the power of a beam of light of any wavelength from ultraviolet to far infrared by comparing the heat from absorbed light with the heat generated by a measured electric current flowing in the light absorber. The concept was developed by Drs. Clark Hamilton, Gordon Day, and Robert Phelan at the NBS-Boulder (Colorado) Laboratories, Jon Geist at NBS-Gaithersburg (Maryland), and Bruce McIntosh of Laser Precision Corp., Yorkville, N.Y.

Various designs, basically similar in approach, have been developed to measure different kinds of light. One version, developed in Boulder, uses a closed-loop servo-system to make automatic measurements. Another version, conceived by Geist, employs a waveform-independent measuring circuit, which makes the measurement less sensitive to the distribution of light across the chopper aperture.

Through effective technological transfer from a government lab to private industry, both types of radiometer are now being marketed by Laser Precision Corp. During a cooperative design and development program with NBS, Laser Precision Corp. made minor alterations to the NBS designs, resulting in their Rs-

3900 series of radiometers now on the market.

The electrically calibrated pyroelectric radiometer complements the traditional instruments of radiometric measurement (such as blackbodies and calibrated lamps, thermopiles, and calorimeters), and, in addition, forms the foundation of a whole new approach to radiometry. It combines, for the first time, sensitivity and convenience with the inherent accuracy of internal electrical calibration.

Since it is calibrated by reference to electrical standards, it provides a short measurement chain between ultimate user and the basic units of mass, length, and time.

## Laser Intensity Stabilizer

The laser intensity stabilizer provides a means of continuously controlling and stabilizing the intensity of a laser beam within narrow limits. It is built as a separate unit, rather than incorporated into the laser itself. Thus, the design can be used with practically any laser desired, and subsequently switched to another laser without major modifications.

The high-speed laser intensity stabilizer uses an extraordinarily fast electronic servo-system to sense the fluctuations in the laser's intensity and rapidly change the transmission coefficient of an active element to compensate. The result is a beam of laser light that contains far less broadband noise than before and allows far more accurate calibration of power levels, more sensitive spectroscopy, and elimination of lengthy experimental runs to check for power-level drift.

This stabilizer was developed by NBS scientists John L. Hall and James

J. Snyder at the Joint Institute for Laboratory Astrophysics (JILA), which is a cooperative venture of the University of Colorado and NBS in Boulder. It can be used with any continuous-wave (CW) laser up to power levels of 2 or 3 watts, but it is particularly useful for controlling the optical pumps of dye lasers, which have noise levels of 5-10 percent with frequency components extending to very high frequencies (about 200 kHz), and gas lasers whose plasma noise also reaches that frequency. The bandwidth of control extends to about 5 MHz and lowers the broadband RMS intensity noise level to about  $10^{-3}$  to  $10^{-4}$  of the dc power in the beam, regardless of the amount of noise originally present, whether 50 percent or 1 percent. The low frequency noise level (below 10kHz) is reduced to approximately the theoretical minimum "shot-noise" level.

Most uses of lasers require some degree of stability in power output; such uses as precision measurements, laser spectroscopy, and calibration of power meters and transfer standards require stability (freedom from noise at high and low frequencies) far in excess of that available from most lasers without the intervention of the operator. The new device allows the operator to simply set the desired power level and then concentrate on the measurement, rather than have to constantly adjust the power output manually. Elimination of the power fluctuations at high and low frequencies may permit dye laser spectroscopy, for example, to achieve 100 to 1000 times better sensitivity.

Since commercial production of the stabilizer has not been arranged, turn page

## IR 100 continued

interested manufacturers should contact the developers at NBS, Boulder, Colo. 80302.

### Dew-Frost Point Apparatus

The dew/frost point apparatus measures the moisture content of the air space of sealed insulating glass. The longevity performance of sealed insulating glass units can be evaluated by careful measurements of water vapor content in the air space between the glass panes—so-called dew/frost point—and its rate of increase. The apparatus was developed specially for this purpose to evaluate the quality and reliability of the sealed insulating glass units.

The dew/frost point indicates the temperature at which water vapor of the air space condenses or freezes on the inner surface of the glass pane.

With previous devices utilized for this purpose, the temperature of the apparatus was controllable within the range of  $\pm 3^\circ\text{C}$ . Using the new apparatus it can be controlled to within  $\pm 0.05^\circ\text{C}$ . It is easy and convenient to use and it is reliable and reproducible.

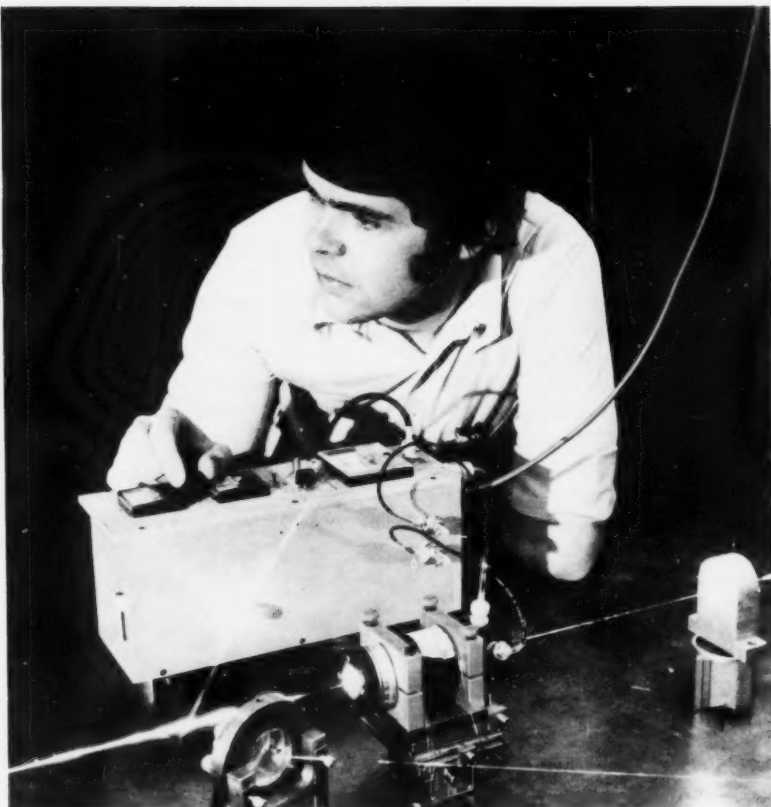
The apparatus was invented by Dr. Mahn Hee Hahn, a mechanical engineer working in NBS' Center for Building Technology. Hahn is an NBS Research Associate under sponsorship of the American Society for Testing and Materials (ASTM) Committee E06—Performance of Building Constructions.

His invention has been patented (U.S. Patent 3,896,658) and adopted as a standard test method by ASTM (ASTM E546-75). The apparatus consists of two metal blocks, upper and lower, which are placed in series with a small air gap in between. The lower metal block is chilled by a

pack of dry ice, which is spring loaded to keep the block near the sublimation temperature of dry ice. The temperature of the upper metal block is controlled by varying the air gap distance between the two metal blocks. This is accomplished by a threaded control ring connected to the housing of the lower metal block.

The dew/frost point is measured by contacting the exposed front surface of the upper metal block, which is mirror finished, against the surface of the sealed insulating glass units, and gradually lowering the temperature of the upper metal block until dew/frost deposits appear on the inner glass surface. The temperature is monitored by a digital thermometer or a bimetallic dial thermometer. Since the dry ice is self contained, the apparatus can be used in any orientation.

The apparatus is being produced commercially by DENNIS Industries of 19444, St. Johnsbury Lane, Germantown, Md. 20767. □



*Dieter Frolich, a visiting scientist at the Joint Institute for Laboratory Astrophysics operates the laser intensity stabilizer that won an I-R 100 award.*



# Fifty-Seven Major Appliance Manufacturers Support Energy Efficiency Program

**F**IFTY seven major appliance manufacturers have agreed to support a voluntary program aimed at achieving a 20 percent average reduction in the energy consumption of new household appliances by 1980.

"These firms account for 93 percent of the retail sales of the appliances covered in the Commerce Department's Voluntary Program for Appliance Efficiency," according to Assistant Secretary of Commerce Betsy Ancker-Johnson.

"I believe that the program will make a significant contribution in achieving President Ford's goal of reducing our dependence on foreign energy sources," the Assistant Secretary said. "In addition, consumers will benefit from the program directly by reduced energy costs resulting from operation of more efficient appliances," she said.

The Voluntary Program for Appliance Efficiency was established by President Ford in a supplement to his State of the Union Message January 15, 1975. President Ford called for a 20 percent average reduction in energy consumption of all major appliances by 1980 and for agreements by major appliance manufacturers to comply with the goals. If agreement could not be obtained in 6 months, President Ford said he would request legislation to establish mandatory appliance efficiency standards.

"Because of the favorable and timely industry response to the President's challenge, our program is moving forward effectively without the need for legislation establishing mandatory appliance efficiency standards," the Assistant Secretary stated.

The Assistant Secretary said the 57 companies supporting the program represent all categories of appliances

for which energy efficiency goals are being set. Electric appliances in the program are room air conditioners, refrigerators, combination refrigerator-freezers, freezers, clothes washers, dishwashers, and television receivers (black and white as well as color). Appliances that use either gas or electricity are water heaters, clothes dryers, and kitchen ranges and ovens.

More than 51 million units of these appliances were sold in 1974 with a retail sales value of \$12.8 billion. The total primary energy consumption of all these major appliances in use today is estimated at the equivalent of 2.7 million barrels of oil per day.

The following proposed efficiency goals, and programs to attain these goals, have been assigned to 13 categories of appliances. These have been published in the *Federal Register* for public comment:

- Room air conditioners, 22 percent reduction
- Freezers, 25 percent reduction
- Refrigerators and refrigerator-freezers, 30 percent reduction
- Electric water heaters, 9 percent reduction
- Gas water heaters, 25 percent reduction
- Electric ranges, 10 percent reduction
- Gas ranges, 30 percent reduction
- Electric clothes dryers, 6 percent reduction
- Gas clothes dryers, 12 percent reduction
- Clothes washers, 10 percent
- Dishwashers, 18 percent reduction

- Black and white television sets, 48 percent reduction
- Color television sets, 42 percent reduction

Final goals for specific appliances may be higher or lower than the average, depending on technical and economic feasibility. (The base year from which improvements in energy efficiency are to be measured is 1972). These final goals are now being prepared for publication in the *Federal Register* by the National Bureau of Standards, which supplies technical support for the program.

In attaining the final goals, each company will formulate its own plan, which may include upgrading the entire line or a portion of the line, eliminating less efficient models, or modifying production mix.

"As in any voluntary program, subsequent economic or other events may cause some participants to withdraw," Dr. Ancker-Johnson stated. "If this should occur to an extent that would jeopardize our overall goal, we will have to reconsider the necessity for a mandatory program and will advise the President of our recommendation."

The proposed goals and programs were developed as a result of comments and suggestions received by The Department of Commerce in response to a March 3, 1975 *Federal Register* notice. Meetings with appliance manufacturers to solicit comments and suggestions were held at NBS.

Other agencies participating in the Voluntary Program for Appliance Efficiency are the Federal Energy Administration and the Office of the Special Assistant for Consumer Affairs. □

## NBS Circulates Voluntary Toy Safety Standards

**A** proposed Voluntary Product Standard that would establish nationally recognized safety requirements for toys intended for use by children up to 14 years of age is being circulated by the National Bureau of Standards.

If the standard is approved, producers and distributors may identify their toys that conform to the standard through appropriate marking, labeling, and advertising. The consumer would be informed that toys which comply with the standard should be safe during conditions of normal use or "reasonably foreseeable abuse." The latter would include instances of children taking toys apart, dropping or throwing them, or using them for purposes other than intended.

The standard is being processed under the Commerce Department's Voluntary Product Standards procedures at the request of the Toy Manufacturers of America. The standard is being circulated to interested groups and individuals for acceptance.

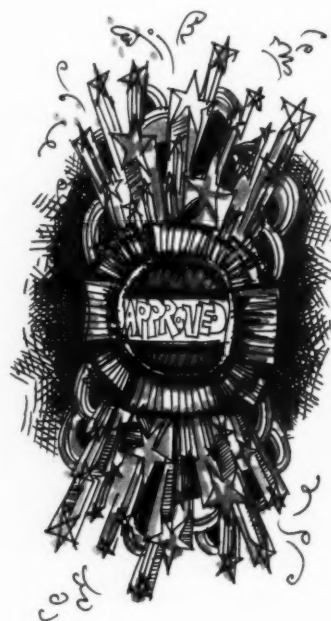
The proposed standard contains requirements for materials quality, flammability, toxicology, packaging film, strings and elastics, electrical or thermal energy, impulsive noise, edges, hazardous points, and projections.

It also contains requirements for wheels, tires, and axles; folding mechanisms and hinges; holes, clearances, and protection of mechanisms; stability of ride-on toys and seats; overload requirements for ride-on toys and seats; tipping of stationary floor toys; confined spaces, small objects; simulated protective devices such as helmets, hats, and goggles; projectiles; and labeling, literature, and marking.

Inspection and test procedures to be used to determine the conformance of toys to the requirements of the standard are also contained.

Articles not covered by the proposed standard include bicycles; sling shots and sharp-pointed darts; crayons, paints, chalks, and other similar art materials; playground equipment; B-B guns; hobby and craft items in which the finished item is not primarily of play value; model kits in which the finished item is not primarily of play value; sporting goods and camping and athletic equipment; musical instruments and furniture; and powered models of aircraft, rockets, boats, and land vehicles.

Copies of the recommended standard, designated TS 215b, are available without charge from the Standard Development Services Section, National Bureau of Standards, Washington, D.C. 20234. □



## Guidelines for Computer Security Published

**T**HE publication of computer security guidelines for implementing the provisions of the Privacy Act of 1974 has been announced by the National Bureau of Standards.

These guidelines, published as Federal Information Processing Standards Publication (FIPS PUB) 41, provide a handbook for use by Federal organizations in implementing computer

security safeguards in order to comply with the Act.

FIPS PUB 41 describes three categories of technical safeguards which can be used to maintain the integrity of personal information and protect it from unauthorized use: physical security procedures, information management practices, and computer system/network security controls.

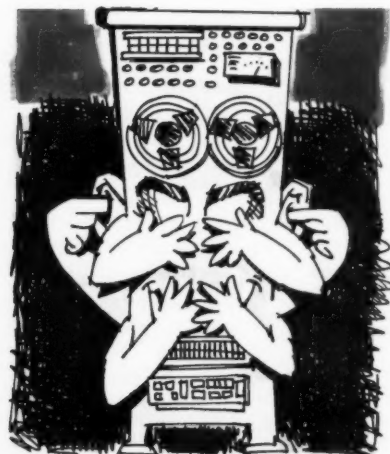
## NBS Workshop to Study Electrocatalysis Processes

The Privacy Act of 1974 imposed numerous requirements upon Federal agencies to prevent the misuse or compromise of data concerning individuals. Federal organizations that process personal data must provide a reasonable degree of protection against unauthorized disclosures, destruction, or modification of personal data, whether intentional or resulting from accident or carelessness. The requirements can be met by the selective managerial, administrative, and technical procedures.

The guidelines in FIPS PUB 41, prepared by NBS at the specific request of the Office of Management and Budget, treat the general problem of computer security in addressing a host of available safeguards. They are also generally applicable to computer security matters unrelated to individual privacy.

The guidelines establish a basis for assessing the risks of unauthorized disclosure of personnel data in automated systems and in developing safeguards to minimize these risks.

Copies of FIPS PUB 41 are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at a cost of 70 cents. Order SD Catalog No. C13.52:41. □



**T**HE processes of catalysis on metals and electrocatalysis on nonmetallic surfaces will be the subjects of two workshops, meeting consecutively, December 8-12 at the National Bureau of Standards, Gaithersburg, Md.

The Electron Factor in Catalysis on Metals will be the subject of the first workshop, meeting on December 8-9. The program plans an interdisciplinary approach, bringing together theoretical physicists engaged in band structure and surface calculations, physical chemists, surface chemists working with clean surfaces and single crystal problems, and practical catalytic chemists.

The keynote address will be delivered by Michel Boudart, Professor of Chemical Engineering at Stanford University.

There will be four panel sessions, each preceded by a formal presentation. The topics will include:

- Experimental techniques providing information on the electron factor, with emphasis on the relation between surfaces in ultrahigh vacuum and real catalysis situations;
- The effects of alloy composition, including the relation between surface and bulk composition, and the nature of bimetallic clusters;
- The relation of geometric considerations to the electron factor, including differences in the electron factor on different crystal faces of the same material, and the role of surface irregularities;
- The theory of electron structure at surfaces, including clean surfaces, adsorbed atoms on clean surfaces, and the molecular cluster approach to adsorption.

The Workshop on Electrocatalysis on Nonmetallic Surfaces, December

9-12, will be concerned with electrocatalysis on compounds used as substitutes for metal electrodes.

Professor Heinz Gerischer of the Fritz-Haber Institut der Max Planck Gesellschaft (Berlin) will address a joint session of the two workshops on December 9. Professor Gerischer's talk on a topic concerned with electron transfer reactions will serve as a bridge between the two workshops.

The second workshop will emphasize studies of electrocatalysis on oxides, sulfides, carbides and similar compounds, and on molecular compounds such as phthalocyanines and other materials of interest to the electrochemistry of fuel cells and batteries.

Six technical sessions, in addition to the Joint Session, are planned, including nine plenary lectures followed by contributed papers and discussions, and a final summary panel discussion. Topics will include:

- Theory of electrocatalysis on nonmetallic surfaces;
- Characterization of nonmetallic electrocatalytic surfaces;
- Electrochemical processes on nonmetallic surfaces;
- Surface reactions of nonmetals under electrochemical conditions;
- Electrochemistry at solid electrolyte interfaces.

Questions about the first workshop on catalysis on metals should be addressed to L. H. Bennett, Metallurgy Division, NBS, Washington, D.C. 20234. Questions concerning the workshop on nonmetallic surfaces should be directed to Dr. Alan D. Franklin or Dr. William S. Horton, Inorganic Materials Division, NBS, Washington, D.C. 20234. □

## Heat Pump *continued*

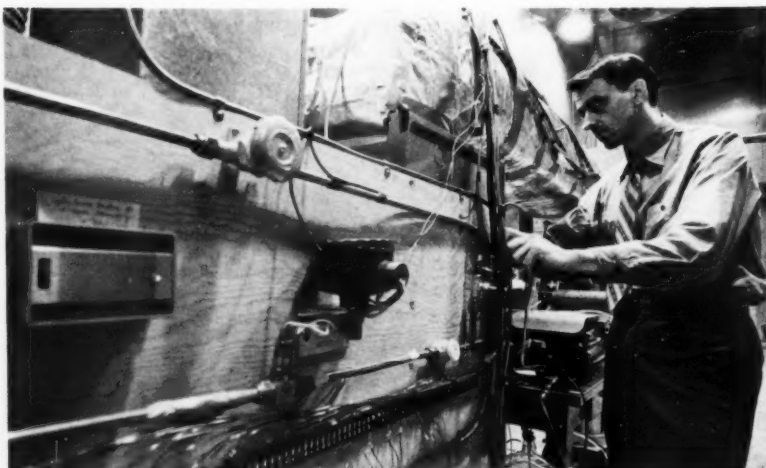
the heat pump is turned off tends to be transferred to the interior space by natural convection. In the cooling mode, however, the coolness remaining in the indoor unit during off cycles is not circulated by natural convection, and most of it is eventually transferred to the basement where it doesn't do any good in cooling the upstairs rooms. The situation might have been reversed, with the heating COP being more affected by part-load operation than the cooling COP, if the indoor unit had been located in the attic, Kelly says. A modification in the heat pump control system which should improve both the cooling and heating COP in basement and attic installations, respectively, would be to have a time delay on the indoor blower which would allow it to operate for several minutes after the compressor shuts off, he says.

The largest adverse effect on the heating performance of the Bowman house heat pump was due to ice building up on the outdoor coil during cold winter days when the temperature dropped below 4.4°C (40°F). Ice buildup not only decreases the performance of the outdoor coil, but energy is also required to defrost the coil, which lowers the effective COP. Kelly believes further research is required to identify the optimum method of defrosting coils in various climates.

### Energy Effectiveness.

To compare the energy effectiveness of the Bowman house heat pump with fossil-fuel heating equipment, Kelly traced the energy consumption of the heat pump back to the primary source energy used by the power plant. The "effective heating COP" which he calculated takes into ac-

*NBS Engineer Didion leads team studying laboratory performance of heat pumps.*



count the fact that usually less than  $\frac{1}{3}$  of the heat energy of the fuel burned at the power plant in making electricity will reach the building and thus the heat pump. This means that for every unit of energy used to produce electricity at the power plant, about half a unit of heat is delivered, on the average, to the interior living space of the Bowman house. Although there is considerable controversy over the seasonal efficiency of gas- and oil-fired furnaces, Kelly believes that the effective seasonal performance of the Bowman house heat pump is equivalent to the performance of many residential gas- and oil-fired heating systems.

"In the Washington, D.C. area there does not appear to be any clear-cut energy-savings advantage in choosing either a heat pump or a gas- or oil-fired heating system," Kelly says. "For areas which have a considerably colder heating season than Washington, D.C., it is likely that gas- or oil-fired residential heating systems would be more energy effective than present-day heat pumps, while a heat

pump would probably be better than gas- or oil-fired units in areas having winters which were milder than Washington, D.C."

Going hand-in-hand with the Bowman house field test are laboratory tests aimed at obtaining a complete definition of the seasonal COP for various climates. Kelly is carrying out tests on a heat pump in one of the Bureau's environmental chambers (where temperature and humidity conditions anywhere in the U.S.A. can be simulated) to load the outdoor unit while simultaneously imposing any building-type load on the indoor unit. The information obtained from the field and laboratory tests will be used to help improve heat pump performance and to predict the seasonal cooling and heating COP's of various heat pumps.

### Advanced Research

Another phase of the NBS research on heat pumps being carried out by engineer Mulroy and technician David Ward deals with evaluating one of the very promising heat pump systems



using existing hardware. Under Didion's direction, they have coupled a heat pump to a Stirling engine, a unique kind of external-combustion engine that has minimal pollution, little noise, and low maintenance associated with it. The engine has two pistons that move up and down in one cylinder, uses a fixed mass of working fluid that constantly flows back and forth between a hot top space and a cold bottom space, and relies on continuous external combustion of fuel to supply heat to the working fluid through the upper wall of a cylinder. Most important, the Stirling engine has the highest theoretical thermal efficiency possible, and a substantially greater efficiency than diesel and other internal-combustion engines in practical use. The NBS work on Stirling engine-driven heat pumps is still in progress and results will not be tabulated for several months.

### Outlook

Compared to other systems, heat pumps now represent a small part of the heating and cooling market, although it is estimated that some 200,000 units will be sold in the United States this year. However, the potential for expanding the heat pump market is greater than that for any other device. The uncertain future of oil and natural gas supplies and the general trend toward all-electric homes offer a unique energy-conservation opportunity for the heat pump.

Other countries have shown interest in heat pumps as well, although at present they are totally dependent on American industry for production models. Western Europe is particularly interested in developing heat pumps for heating only, because their

climate does not require summer air conditioning. NBS is currently engaged in a cooperative program with the Building Research Establishment of England which will enable both countries to benefit from ongoing research projects on heat pumps. The program includes exchange of lab and field data on the dynamic perform-

ance of heat pumps, comparison of different computer models of heat pumps, and joint development of testing procedures to evaluate the operating performance of heat pumps. The outcome of such cooperative efforts as well as the NBS research may well help to bring a heat pump into your future. □

## Thinking about a Heat Pump for Your House? Read on...

Installing a heat pump in an existing house can be an expensive proposition, unless both your central furnace and air conditioner need replacement at the same time. However, many new home builders now offer potential buyers the option of a heat pump instead of electric resistance heating. Whether you are thinking of retrofitting your house with a heat pump, or buying new, here are a few things you should know:

- The Air-Conditioning and Refrigeration Institute (ARI) publishes a directory containing manufacturers' data for residential heat pumps that have been tested under standard ARI conditions. (Remember that these conditions are steady-state full-load conditions and may or may not represent real-life conditions). The directory lists the capacity of different heat pumps in British thermal units (Btu's) and the power input in watts for the heating and cooling modes

of the pump. The ratio of capacity to power input is known as the Energy Efficiency Ratio. The higher the EER, the more efficient the heat pump. The directory is updated twice a year and can be purchased for \$1.00 from the Director of Engineering, Air-Conditioning and Refrigeration Institute, 1815 N. Fort Myer Drive, Arlington, Va. 22209. Ask for the Directory of Certified Unitary Air Conditioners, Unitary Heat Pumps, Sound-Rated Outdoor Unitary Equipment and Central System Humidifiers.

- It pays to buy your heat pump from an authorized dealer, who can help advise you on the proper size unit for your house, provide a planned service and/or maintenance contract, and implement the factory guarantee. Proper installation and servicing are essential for satisfactory operation and will minimize inconvenient and costly repairs.

## Heart continued

Committee F-4 on Surgical Implants, and Committee F-1 on Electronics, and the International Society for Hybrid Microelectronics.

Various resources for reliability and test information such as the Reliability Analysis Center and the Government Industry Data Exchange Program were reviewed, as were services available for bibliographic searches of the government report literature.

The conference also made available a list of various independent organizations that can provide procurement, assembly, testing, and failure analysis services for small companies that cannot efficiently provide the service for themselves.

Despite the fact that only one workshop was planned, attendees at the closing session recommended that follow-up action be taken and that NBS should be the focal point of such action. One recommendation was that NBS hold an annual 3-day meeting devoted to specific problems of interest to the pacemaker community.

The application of electronics to the medical field has produced beneficial results in providing instrumentation for more effective diagnosis, patient monitoring, and device-aided therapeutics. Much of this progress is due to the development and availability of improved electronic components, especially in the case of pacemakers where size and reliability are prime factors.

NBS efforts to make available experts and sources of information to the pacemaker and electronics industries are helping to assure that the critical needs for high reliability of life-sustaining pacemakers are being met. □

## Sealants continued

According to Chow, the current method of topical fluoridation uses one of several fluoride compound solutions, including stannous fluoride, sodium fluoride, and acidulated phosphate fluoride (APF). These solutions form calcium fluoride ( $\text{CaF}_2$ ) on the surface of the tooth enamel, a portion of which eventually is converted to fluorapatite ( $\text{Ca}_5[\text{PO}_4]_3\text{F}$ ) in the enamel, the desired end product. In the process, a certain amount of the original tooth calcium is lost.

"These solutions were developed under the philosophy that the more fluoride you get in the better," explains Brown. "We're getting away from that and the calcium loss, towards a better use of the fluoride."

The new procedure, developed by Chow and Brown, substitutes for the acid solution one of a number of basic phosphate fluoride solutions (BPF). The advantage of the BPF treatment, said Chow, is that the fluorapatite is formed without the additional formation of calcium fluoride.

Recently, Chow and Brown have discovered a bonus effect. If you apply a BPF solution after etching the teeth for the sealant, you reduce an undesirable by-product of the etching process, dicalcium phosphate dihydrate, which may also act to loosen the sealant.

Their report, "Topical Fluoridation of Teeth Before Sealant Application," appears in the September-October issue of the *Journal of Dental Research*.

The new technique is still experimental, and will probably not be commercial for another 5 years. However, Brown hopes to avoid the expensive and time consuming procedure of a standard clinical test.



Topical treatment: A fluoride gel, in this case flavored orange, is squeezed into a tray. The mouth-shaped tray is then fitted over the patient's teeth and held in place for about four minutes as the fluoride combines with the tooth calcium.

With cooperation of staff dentists and a number of patients, Brown hopes to test the new method on patients who wear dentures with an accelerated test.

Some of the teeth in the dentures, which are normally plastic or porcelain, would be replaced with "real" teeth. With some teeth treated with BPF and others left as controls, the teeth can be "stressed" severely with direct applications of sugar solution every half hour or so. In this way, according to Brown, the long process required to produce detectable tooth decay can be compressed into a week or so.

Although their tests so far seem promising, Chow and Brown are inclined to be cautious about future applications of BPF treatment. "These results," their report concludes, "suggest the possibility of fluoridating the acid-etched enamel, before sealant application, without weakening adhesion of the sealant." □

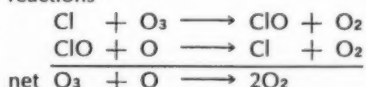
## Ozone continued

pounds on the ozone shield. But predictions made on the basis of these models depend directly on the validity of the data fed into them. This area of stratospheric research recently received an assist from other NBS chemists. Dr. David Garvin and Dr. Robert F. Hampson, Jr., have published new, carefully evaluated chemical kinetic and photochemical data to be used by scientists modeling atmospheric chemistry.

The tables provide the most up to date information on the rates of 271 chemical and photochemical reactions important in the stratosphere, with recommended values for 160 of these reactions. The data were culled from more than 100 laboratories with new data supplied where needed by NBS. Preparation of the tables was supported by the Climatic Impact Assessment Program of the Department of Transportation and the NBS Office of Standard Reference Data and Office of Air and Water Measurement. As new information becomes available, the data tables are revised.

In fact, shortly after the tables were published, Dr. Michael J. Kurylo and Dr. Walter Braun, chemists in the Institute for Materials Research, completed a study of the rate of reaction

for one of the crucial reactions in the Molina-Rowland theory. The pair of reactions



is believed to be the principal cycle by which chlorine atoms released from fluorocarbons in the stratosphere destroy ozone.

Kurylo and Braun studied the first of these reactions and measured how fast the reaction occurs (the "rate of reaction") over the range of temperatures and pressures found in the stratosphere.

Their results indicate a slower rate of reaction, by about 50 percent at stratospheric temperatures, than the values used by Molina and Rowland in their first computer estimates of the extent of ozone destruction by chlorine compounds. The NBS results have been validated by parallel studies in two other laboratories in the United States and one in the United Kingdom.

The new lower value has the effect of slowing down the rate of the predicted effect of chlorine atom-catalyzed destruction of stratospheric ozone, according to Kurylo and Braun. Although their study provides

more accurate data by which computer predictions of ozone destruction can be made, the chemists caution that their results neither prove nor disprove the validity of any particular predictive models. To do this, direct experimental evidence is necessary.

## Search Continues

Meanwhile, researchers at NBS, NOAA, and other laboratories around the world have stepped up their search for direct experimental evidence in order to determine the validity of the Molina-Rowland theory. Some scientists, who have questioned the theory, suggest that chlorine compounds from natural sources such as the ocean may play a more important role in determining the amount of chlorine atoms in the stratosphere than the fluorocarbons. This possibility is also being investigated. Unlike some research—where the eventual payoff or application is years away—the research on fluorocarbons will be the basis of decisions in the next few years by the governments of many countries that will not only affect the future use of fluorocarbons, but the lives of virtually everyone on earth. □

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